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INTERNATIONAL COOPERATION ADMINISTRATION
OFFICE OF INDUSTRIAL RESOURCES

TECHNICAL INQUIRY SERVICE

CRUSHED ICE AND PACKAGE ICE CUBE PLANT

FOREWORD

The Technical Inquiry Service answers inquiries from overseas on factory or commercial establishment, operation, management, and engineering. This report is one of a series based on these technical inquiries.

This report is designed to provide only a general picture of the factors that must be considered in arriving at a decision to establish a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice on the spot in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

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The report was prepared by The Institute for Cooperative Research, University of Pennsylvania, Philadelphia, Pennsylvania

For further information and assistance, readers should contact their local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

Crushed Ice and Package Ice Cube Plant.

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CRUSHED ICE AND PACKAGE ICE CUBE PLANT

The following is a plan for the small-scale production of crushed ice and ice cubes at a yearly production rate of 100 tons. The final product is made by two machines with individual capacities of approximately 400 pounds per day and which are capable of operating automatically and continuously. Manual attention is required only in bagging and storing the fabricated ice cubes.

The ice cube making machines are provided with a filtering and chlorinating system ensuring a pure and safe product.

The crushed ice is made by a separate machine with no water purification.

The only ingredients which must be steadily supplied are the available drinking water and a commercially prepared bleach solution, and the available electric power.

The estimated initial capital investment will be approximately $5,000.

I. General Description of Process

For an average yearly production of 100 tons the daily production will approximate 570 pounds of ice cubes and the crushed ice production is assumed to be about 300 pounds per day.

For the ice cube manufacturing, two machines with individual productivities of 400 pounds per day give the required daily production and in addition allow for periods of increased demand. Both machines are equipped with storage bins which along with an additional storage locker provide for such high demand periods.

The crushed ice can be supplied by a single crushing machine with a capacity of 300 pounds per day.

All three ice making machines both freeze the ice and give the desired shape and therefore the only demand is for a water supply for the machines. The water for the crushed ice machine was considered sufficiently pure if it approximated the city water supply and thus no treatment is to be provided. The water for the ice cube machines must be considerably purer and a filtering and chlorinating system is provided for this purpose.

The purification system for the ice cube machines consists of two main parts. First the city water, which has been considered questionable as to its purity at times, is filtered by a sand filtering medium. The filter is fitted with a piping system so that it can be washed with water that has already been filtered and chlorinated. The filtering removes all sediment and rust and helps ensure a clear final product.

The filtered water is then piped to a tank which is maintained at a constant level by an electric conductivity probe which shuts off the water when a certain pre-determined level is reached and reopens the control valve when another lower level is reached. This provides a tank of filtered water as a constant source for the chlorination pump. A source of chlorinating solution is also to be available to the chlorinating pump. (See operating instructions).

The pump has two pumping heads both of which are adjustable. One is set to pump at near its minimum; the other near its maximum capacity and the two streams are drawn into the pump and mixed. The chlorinated water is then pumped directly to a storage tank which provides a supply of pure water in case of water failure as well as allowing hold up time for the chlorine solution to kill all bacteria in the water. The chlorine level in the tank is to be maintained at just less than one part per million by weight. (See operating instructions). The storage tank is provided with a pressure controller so that when the pressure in the tank reaches a predetermined maximum the controller shuts off the chlorinating pump and at a lower pressure the controller restarts the pump. This control ensures a workable pressure in the ice making machines.

The water in the storage tanks is then piped directly to the ice making machines. The only possible source of impurity in the water at this point are certain harmless, dissolved minerals and the ice machines listed in the Equipment section provide constant circulation which rinses the freezing area and keeps the ice cubes free of any cloudiness which could be caused by these impurities.

The controllers in the system are automatic and use relatively little power. The pressure controller is a pneumatic device; the pressure in the tank activating a spring and bellows which has a double throw action enabling the single controller to both make and break the operating circuit of the chlorinating pump.

The liquid level controller depends on the conductivity of the filtered water in the tank. A probe contacting the water either makes or brakes the control circuit; this signal is transmitted to an activating motor which opens or closes a control valve. ((10) on Figure I)

II. Operating Instructions.

A. Start up

When all equipment has been installed and inspected within the framework of any special local laws or ordinances the ice production can be begun in the following way.

For the crushed ice machine: open valve (9) (see Fig. I) in the city water line and switch on the machine. For the ice cube machines: open valve (1); set valve (2) (the operating valve on the filter) to forward filtration; close valves (3), (7), and (8); open valve (4); switch on the liquid level controller; open valve (5); switch the pump to manual control and then switch the pump on, (see below); when tank is nearly full open valve (7) and switch pump to automatic control and operate in this manner, allowing the water to flow to the drain from the storage tank, for several hours, thus allowing the lines to clear out and allowing the chlorine solution to reach an equilibrium with the untreated water; at the end of this time close valve (7) and open valves (5) and (6); switch on the ice machines and set to desired size.

Before the actual start-up it will be necessary to connect one of the pumping heads to a suction line leading into the constant-level tank. The other head is to be connected to a suction line (plastic tubing is supplied) leading into the hypochlorite solution. The hypochlorite pumping head should be set to pump the minimum possible amount (about .4 gals. per hour). The filtered water should be pumped at the maximum possible amount (about 60 gals. per hour). For a properly mixed hypochlorite solution (see below) this should result in a treatment of chlorine of three parts per million, and should be sufficient to destroy any bacteria. Since any such impurities are present in unpredictable amounts a constant surveylance must be maintained and this is accomplished by a sampling and testing procedure. (see below under "Continuous Operation").

A properly mixed hypochlorite (or chlorine) solution is obtained by diluting, with water taken from the storage tank, a commercially prepared, concentrated hypochlorite solution. Such commercial solutions are about 15% available chlorine.

To mix the solution: Draw 20 gallons of chlorinated water from the tank through valve (7).

From the supplier of the bleach, ascertain:

1. available chlorine percentage (approx. 15%)
2. specific gravity

Add the following amount of hypochlorite solution (bleach).

$$\frac{(100)}{(\text{available chlorine percentage})} \times (.0575) = \text{pounds to add.}$$

$$\frac{(2613)}{(\text{specific gravity})\ (\text{available chlorine percentage})} = \text{c.c. to add.}$$

The number of c.c. to add can be measured by an ordinary graduated cylinder. This will give twenty gallons of dilute hypochlorite solution which will have to be replaced about every other day. See following Table 1.

B. Continuous Operation

After start-up, continuous operation follows with no further manipulation. That is: valves (1), (4), (5), (6) and (9) are open; valve (2) is set for filtering; valves (3), (7), and (8) are closed; both automatic controllers are switched on as are all three ice machines. The ice is removed from the machines as quickly as the bins are filled. This enables the machines to operate full time. A more complete discussion of valve (2) is given on p. 8.

While the operation is continuous special manual attention must be given to the chlorine content of the water in the storage tank. If a sudden rise should occur in the amount of bacteria in the water, the chlorine solution will have to be made more concentrated. If there is a drop in the bacteria content, the chlorine solution will have to be made more dilute. In either event the water in the storage tank must be periodically tested. The frequency of testing will depend on the confidence which is placed on the purifying system which the city maintains. Testing once or twice a day would be recommended. Instructions for testing accompany the test kit (see p.7).

The testing procedure consists of drawing off a sample from valve (7) and testing the sample with a special test kit, (see Equipment). If the chlorine content should be more than 0.5 ppm above or below the 0.5 - 1.0 ppm (parts per million) range, a new hypochlorite solution must be mixed and used in place of the one given the unsatisfactory test. For example, if the test shows no available chlorine in the storage tank and a 3.0 ppm solution is being pumped, a new solution should be made (according to Table I) at 4.0 ppm and this should be pumped and tested to see if it is sufficient. If for any reason a high level of impurity is detected the storage tank should be emptied and operations halted.

When a new chlorine solution is substituted for one that is found unsatisfactory or when a solution is used up and must be replaced the pump need only be switched to manual control and turned off while the new containers of hypochlorite solution is fitted with the suction tube.

During continuous operation, periodic cleaning of the filtration system will be required. About once every one or two weeks this can be done ensuring

a pure filter medium. The procedure requires closing valves (5) and (6) just after the pump has switched off and the storage tank is at maximum pressure; closing valves (1) and (4); opening valves (8) and (3); and turning the operating valve (2) to the washing position. The waste material will then flush through valve (3) to the drain. After about ten or fifteen minutes the procedure is reversed and normal operations are resumed.

During the duration of continuous operation the cubes and crushed ice are bagged in 15 pound lots and stored in the freezer. This is a manual operation requiring only a weighing scale and a scoop and supply of special bags, (see Equipment).

III. Equipment

A. Ice cube machines:

Two York WC40 machines, capacity 400#/day, specify: no crusher, 160 pound bin, voltage available.

Contact: Ajax Philadelphia, Inc.
3617 - 25 Lancaster Avenue
Philadelphia 4, Pennsylvania

B. Crushed ice machine:

One York AF-30 machine, capacity 300#/day, specify: bin, voltage.

Contact: Ajax Philadelphia, Inc.
3617 - 25 Lancaster Avenue
Philadelphia 4, Pennsylvania

C. Chlorinating pump: (see special instructions)

One Proportioneers Duplex Chem-O-Feeder, model 2-47, specify: voltage.

Contact: Proportioneers, Inc.
Division of B-I-F Industries, Inc.
Providence 1, Rhode Island

D. Storage freezer

One Husswann RL-30 storage refrigerator, specify: voltage available.

Contact: Engineering and Refrigeration, Inc.
3325 Chestnut Street
Philadelphia 4, Pennsylvania

E. Filter:

One American Water Softener light industrial filter, size unit - 12.

Contact: American Water Softener Company
4th and Lehigh
Philadelphia 33, Pennsylvania

F. Controls:

One R7089B Versatran liquid level controller.
One M604B electric motor - valve body combination.
One L604A pressuretroler.

Contact: Minneapolis - Honeywell Regulator Company
Industrial Division
Philadelphia, Pennsylvania

Specify: voltage available.

G. Storage Tank:

Specify: steel, hot dipped galvanized, in and out, (for 100 pounds pressure).
external dimensions: 3'0" diameter
5'0" height
support on (3) angle iron legs.
(4) threaded outlets for standard 3/4" piping
(1) in top of tank
(1) in bottom of tank
(2) 3"-6" from bottom
tank to have flanged and dished heads for 100 pounds pressure
(1) threaded outlet for standard ½" piping in center of tank top.

Contact: Philadelphia Iron Works, Inc.
D Street and Erie Avenue
Philadelphia 24, Pennsylvania

The following items should be locally available. If not, the address of a supplier for each item is listed.

Crock for hypochlorite solution:

Specify: 20 - 30 gallons capacity, ceramic, with cover.
Contact: William, Brown & Earle
906 Chestnut Street
Philadelphia, Pennsylvania

Liquid level tank:

Specify: steel, with tank cover.
external dimensions 1'6" diameter
2'0" height

Contact: Philadelphia Iron Works, Inc.
D street and Erie Avenue
Philadelphia 24, Pennsylvania

Bags for delivery and storage:

Specify: two-ply, wet strength

Contact: Miller, Tompkins & Company
East Rutherford, New Jersey

Scale:

Specify: Detector dial scale, 0-50 pound range.

Contact: J.J. McIntyre & Sons
514-16 Knorr Street
Philadelphia, Pennsylvania

Test Kit for chlorine determination:

Contact: Hachik Bleach Company
50th Street & Wynnefield Avenue
Philadelphia, Pennsylvania

The following items will be available locally:

Valves and piping:

Specify: 3/4" standard steel pipe, 3/4" brass globe valves.

Hypochlorite solution:

(see operating instructions concerning additional information required)

III. Special Instructions - re: page 5.

For installation of the chlorinating pump and the pressure controller which will control it, specify a simple switching device be installed which will allow for both manual and automatic control. The switch should be installed in the line between the controller and the pump thereby enabling the pump to be taken off automatic control and placed on manual control and vice versa.

Valve (2), designated above as the operating valve is an integral part of the water filter. It can be positioned in any one of four ways two of which are of interest in this process: forward filtration flow and backwa l flow for washing the filter medium. The set positions are clearly labeled.

IV. Hypothetical Weekly Schedule Illustrating Storage Facilities.

A hypothetical schedule for a week of particularly high demand will illustrate the flexibility of the proposed equipment.

The expected demand, at present, would require an output of some 300 pounds of crushed ice and between 500 and 600 pounds of ice cubes per day. Now, assuming a constant demand for crushed ice and an increased demand for ice cubes for this fictitious week as follows:

	Crushed	Ice Cubes	
Monday	300	500	(300)
Tuesday	300	500	(300)
Wednesday	300	500	(300)
Thursday	300	500	(300)
Friday	300	700	(100)
Saturday	300	1200	
Sunday	300	500	(300)
	2100	4400	

The peak demand on a Saturday would be handled easily in this case because the excess capacity (in parenthesis at the right) can be stored in the freezer.

The Saturday demand of 1200 pounds would be met simply by delivering the stored ice during the day. The storage capacity allows for a demand even greater than this.

V. Comments On Layout.

For any proposed layout of the equipment the required floor area will be slightly in excess of 200 square feet and the height required is about eight feet. The area must have at least one drain available, or more conveniently two. A work bench about ten or twelve feet long would facilitate the bagging process by providing a roomy working area for weighing and bagging the ice cubes.

No matter what the final arrangement, several things must be kept in mind: the storage tank and the filter must be readily accessible to an operator for purposes of manipulating valves; all ice machines must be accessible for removing the product; the hypochlorite tank must be accessible for replacement (for this reason, figures II and III show the chlorine solution tank on the floor); and the freezer must have sufficient space for loading and unloading.

All of the major equipment is readily maintained. The pump probably requires the most attention and, as shipped, contains a set of spare parts for any needed repair.

TABLE I

Formula for preparation of dilute hypochlorite solution:

For pumping a solution which is:	Add the number of c.c.'s given by (X)/(S.G.)(%)*
1 ppm chlorine	(X) = 341
2	1478
3	2613
4	3750
5	4887
6	6024
7	7161
8	8298
9	9435

* (S.G.) = specific gravity of hypochlorite.
(%) = available chlorine percentage.

Referring to the equations of p.4: the first equation specifies the number of pounds of bleach to be added to 20 gallons of water to give a three parts per million (ppm) chlorine solution; the second equation simply states the same thing only in terms of the number of c.c.'s of liquid bleach which are required. The ease of handling the liquid form of the bleach favors it over the solid form and the second equation is the one which will determine the amount to be added.

The above table allows rapid determination of the number of c.c.'s of bleach to be added to 20 gallons of water to give any concentration of chlorine solution between 1 and 9 ppm. For example:

for a 5 ppm solution, assuming:

S.G. = 1.5
% = 15

from Table 1, X = 4887

$$(4887)/(1.5)(15) = 217 \text{ c.c.'s}$$

For a 3 ppm solution the equation is the same as on page 4.

TABLE II

Initial Capital Investment

2 Ice machines (no crusher, 160# bin), $800.	$1,600.
1 Ice Crusher, (with bin)	560.
1 Freezer and refrigerating motor	800.
1 Stoage tank	500.
1 Chlorinating pump	550.
1 Filter	195.
1 Pressurtroler	25.
1 Liquid level controller	50.
1 Control valve	75.
1 Test kit	10.
Piping and valves, etc.	350.
Scale	110.
Tank	100.
Crock	20.
Total (not installed).....	$4,935.

These prices F.O.B. the New York-Philadelphia Area, add about 10% ($500.) for shipping.

TABLE III

The following is a list of the items which must be considered in arriving at an estimate of the expense of operating continuously.

1. Electrical power:

Pump	0.25	H.P.
Ice machines	3.20	H.P.
Freezer	0.75	H.P.
Controllers	0.00	(negligible)
Total	4.20	H.P.

2. Bleach:

   Cost is negligible

3. Water:

   2,000 gallons per day (based on 24 hour day)

4. Labor:

   28 hours per day (based on a single operator on a 24 hour day and 4 hours per day delivery time)

5. Maintenance:

   Assume 6% of capital cost (approx. $350 per year)

Local costs can be applied to these figures to arrive at an operating cost. The application of figures available in the U. S. would give a meaningless result.

TABLE IV

Bulletin references:

Refer to the following company bulletins for additional information.

Item A: Form ICE 59 - 2005
York Corporation

Item B: (same as above)

Item C: Sup. bulletin 1225-2
Builders Iron Foundry

Item D: Form 564 - 156N5
Husswan Refrigeration, Inc.

Item E: Booklet 725 -2M - 5/55
American Water Softener Co.

Item F: Specification S1017-1
Catalog C800-1
Catalog C101-1a
Minneapoles - Honeywell

Note: Mention of the name of any firm, product, or process in this report is not to be construed as a recommendation or indorsement but merely as a citation that is typical in its field. Commercial directories generally list names of additional sources.

To obtain copies of any enclosures, catalogs, bulletins and other reference material mentioned in this report, please write directly to the indicated source of issue or supply.

Report Prepared by

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for

THE INSTITUTE FOR COOPERATIVE RESEARCH

UNIVERSITY OF PENNSYLVANIA

FIGURE I
FLOWSHEET OF PROCESS
(NUMBERS REFER TO OPERATING INSTRUCTIONS).

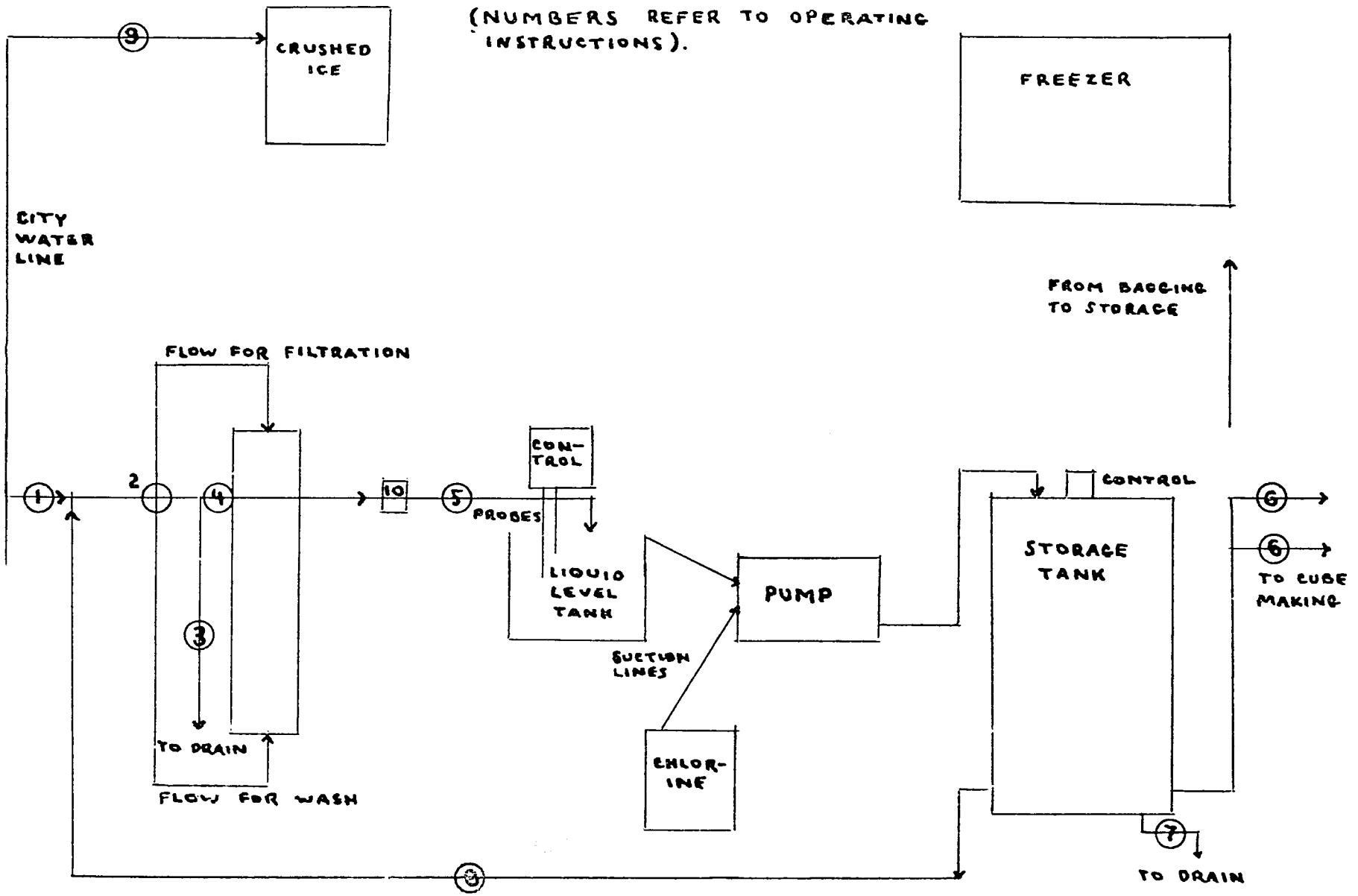


FIGURE II-A
PROPOSED LAYOUT NO. 1
TOP VIEW
TO SCALE: 25/64 IN. = 1 FT.
TOTAL AREA = 234 SQ. FT.

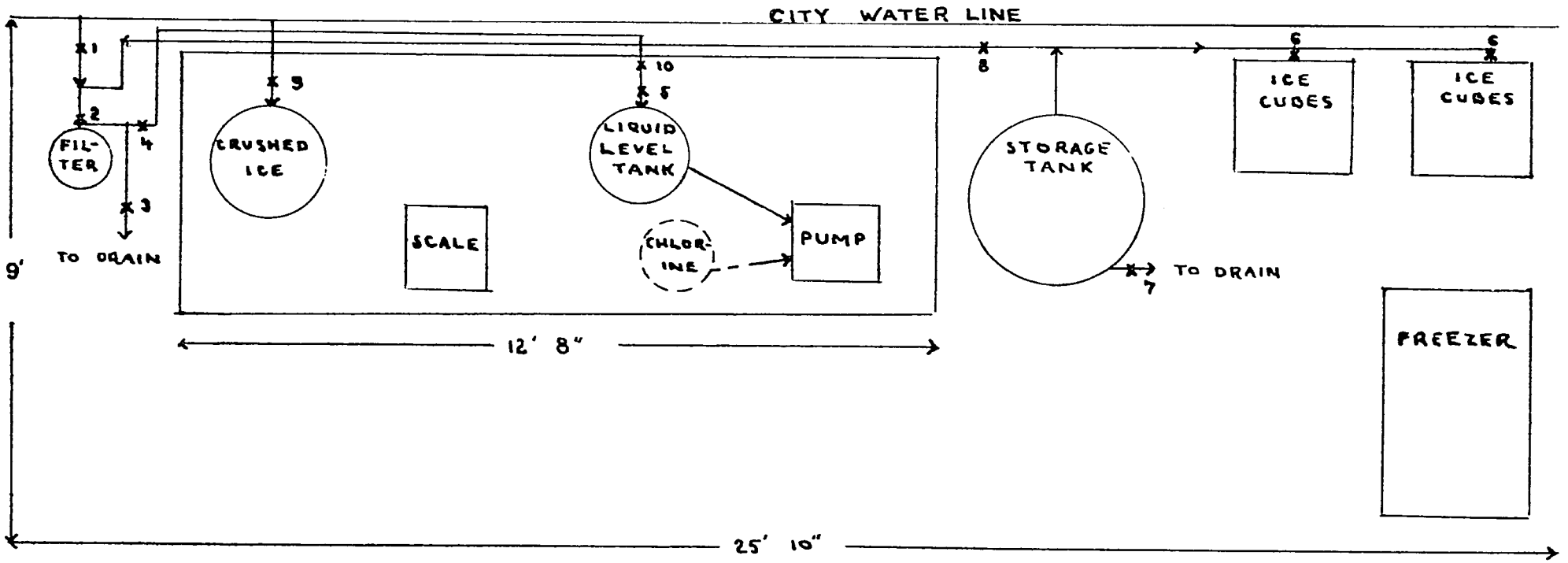


FIGURE II-B
PROPOSED LAYOUT NO. 1
FRONT VIEW
TO SCALE : 25/64 IN. = 1 FT.

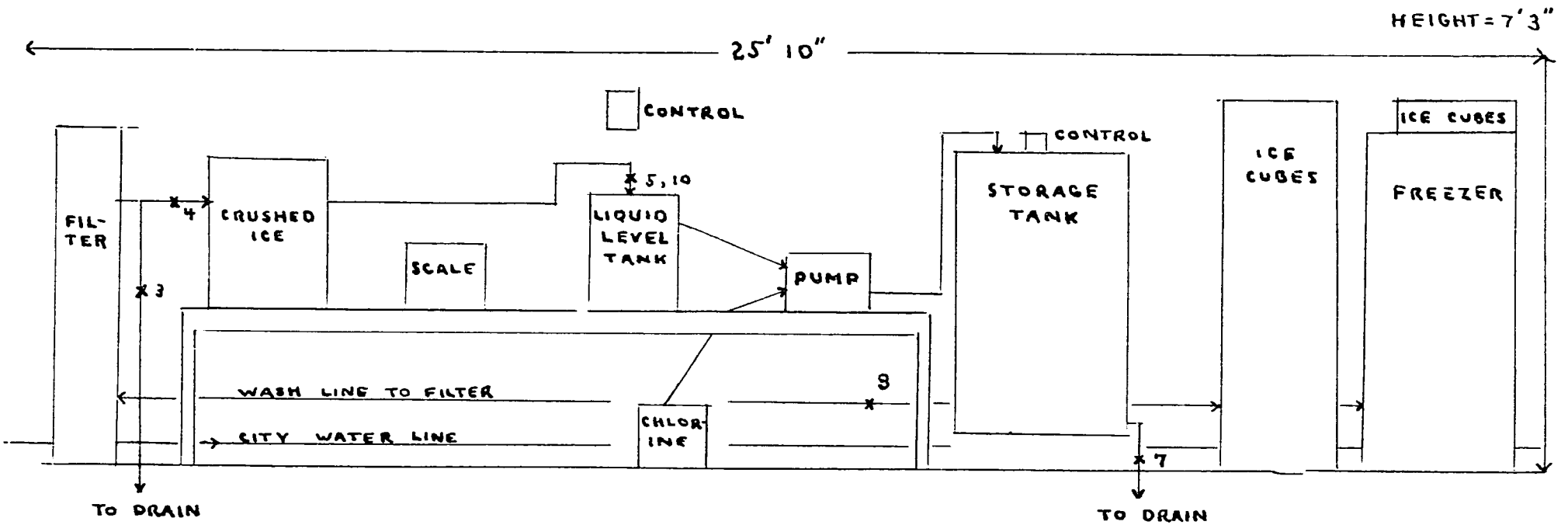
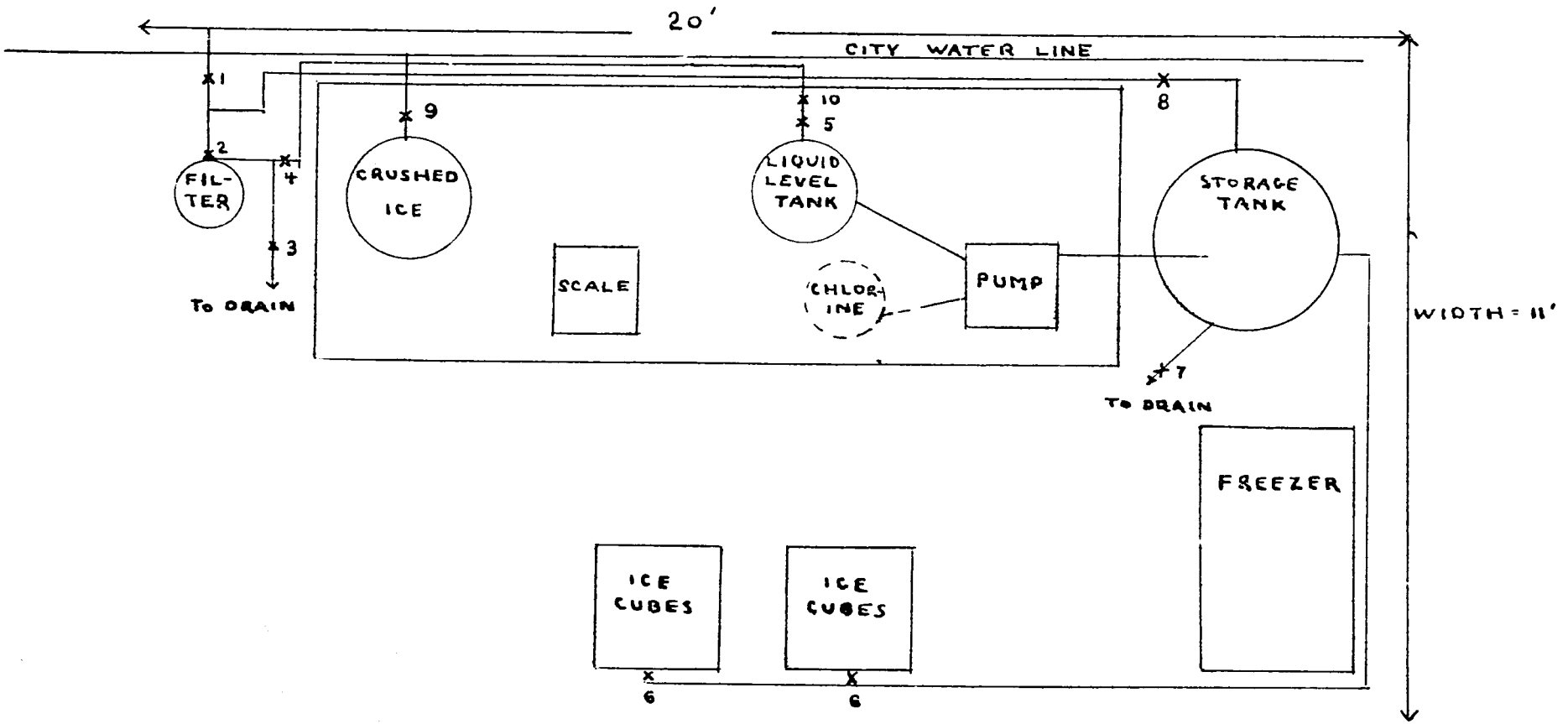
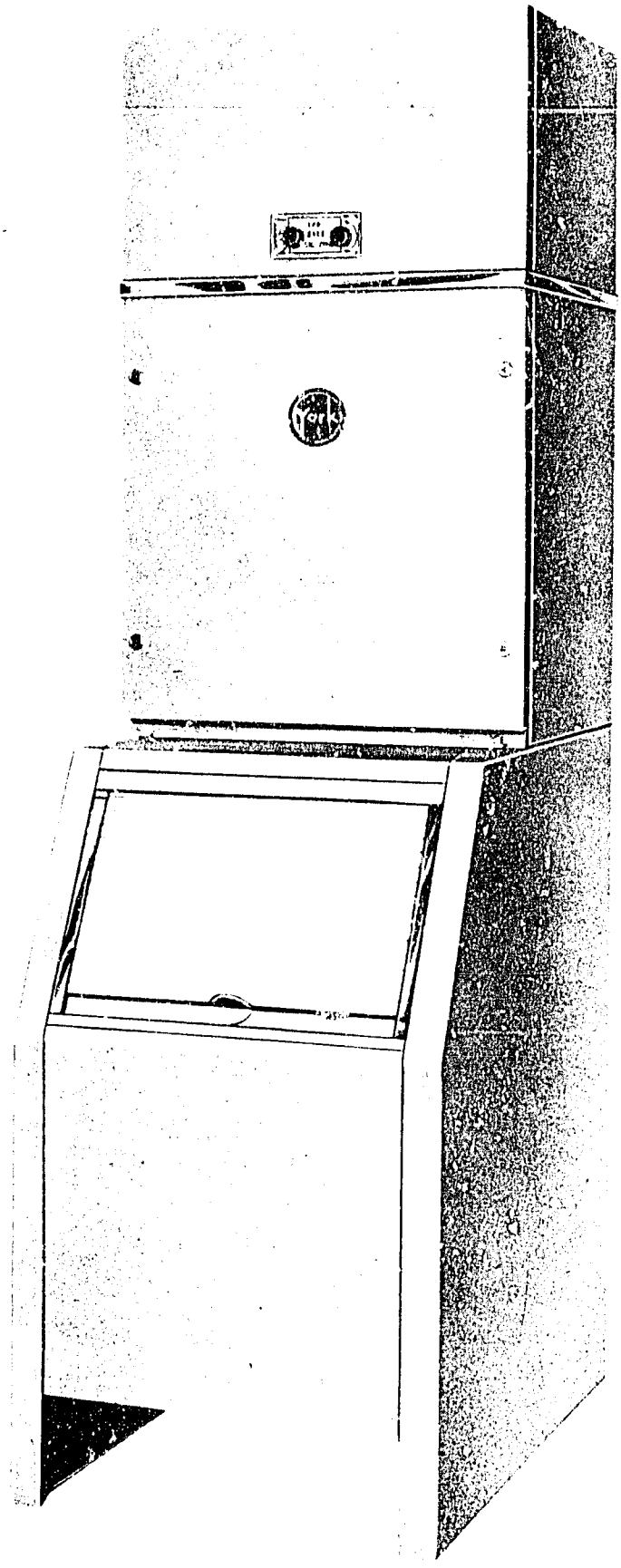
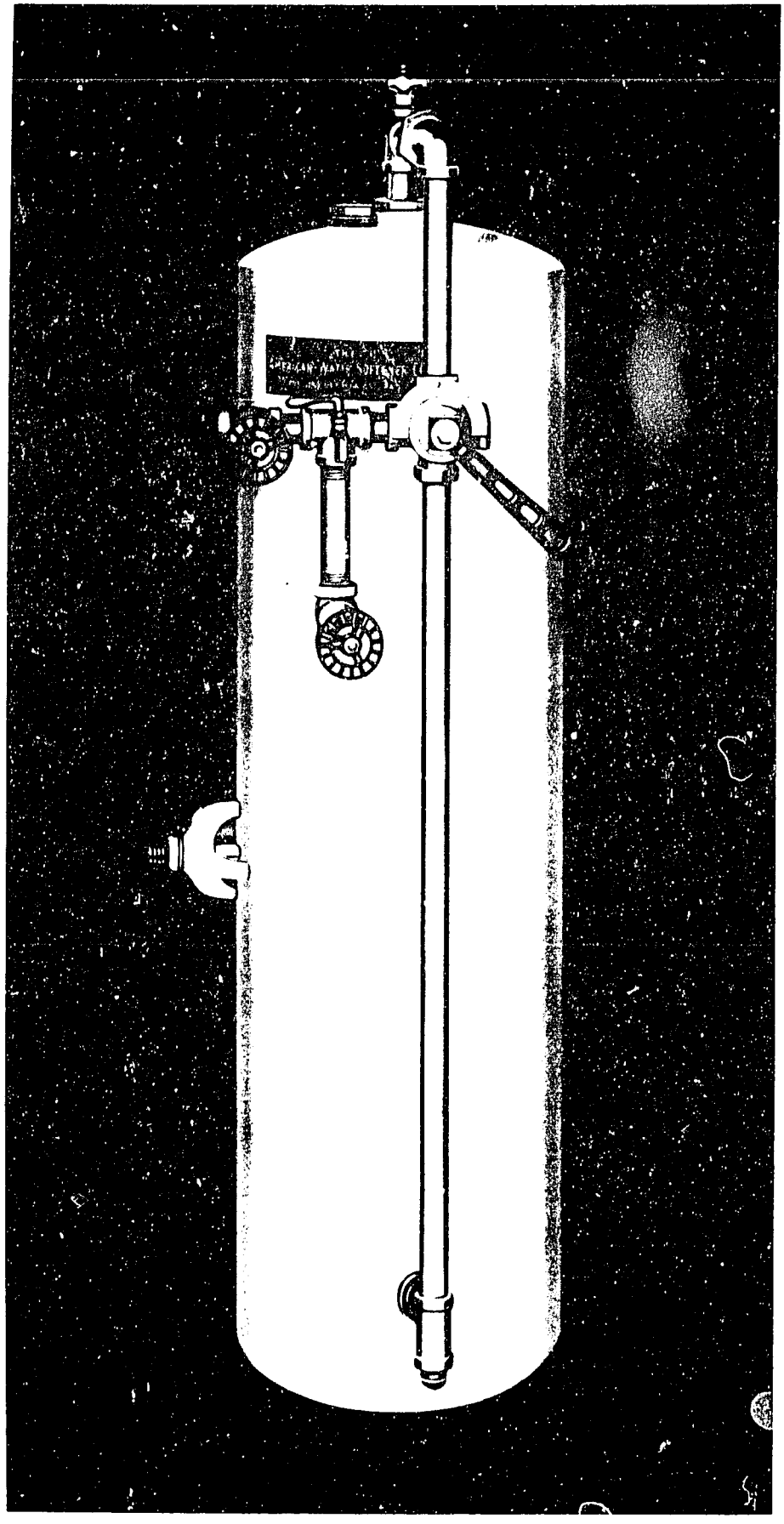


FIGURE III
PROPOSED LAYOUT NO. 2
TOP VIEW
TO SCALE : 25/64 IN. = 1 FT.
TOTAL AREA = 220 SQ. FT.

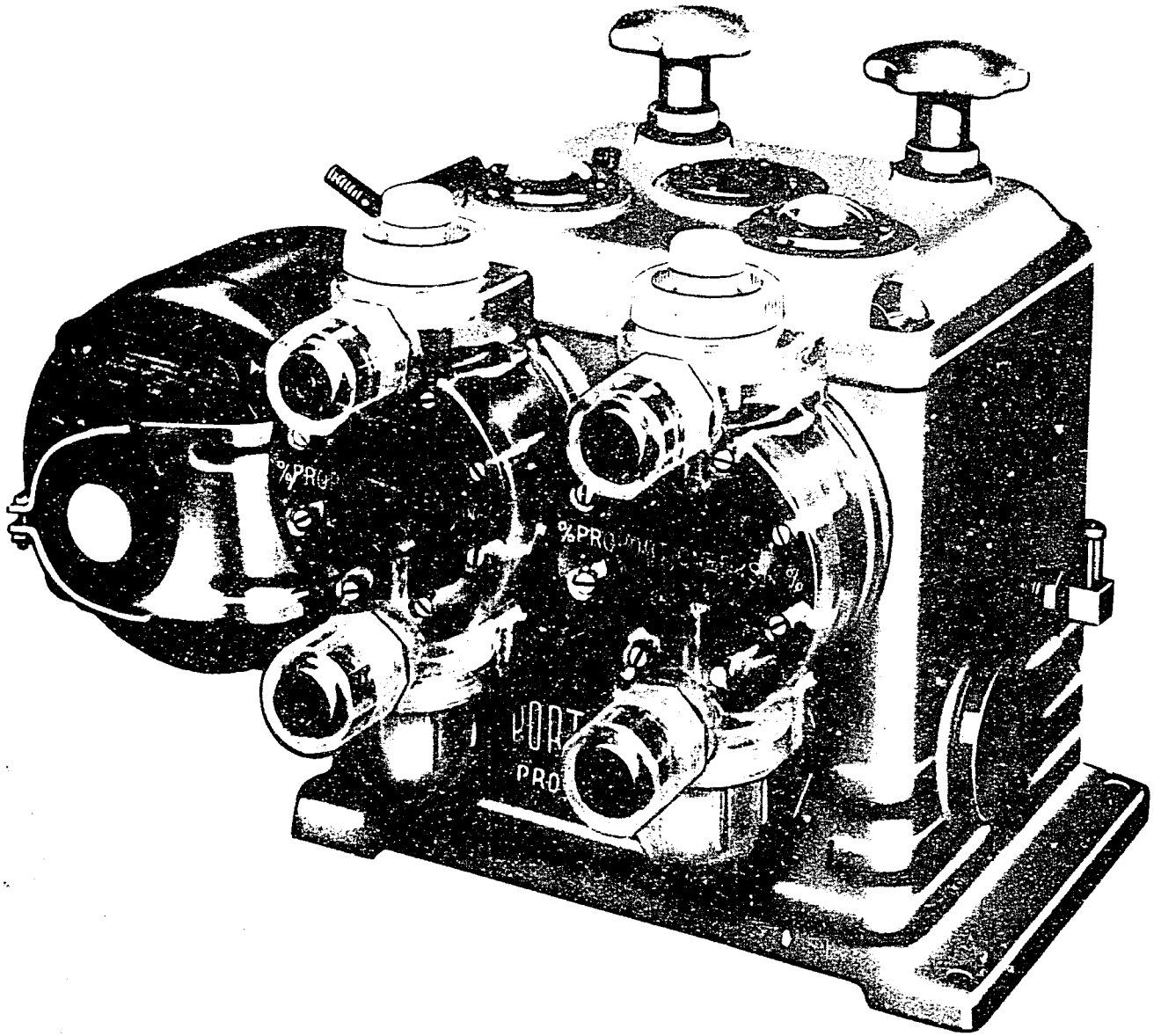




Size Selector



Light Industrial Filter Unit, Size 12



Duplex Chem-O-Feeder, Model 2-47